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ABSTRACT

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TECH MEMO

INTERACTION OF ABILITIES AND ANXIETY WITH AVAILABILITY OF OBJECTIVES AND/OR TEST ITEMS ON COMPUTER-BASED TASK PERFORMANCE

Paul F. Merrill and Nelson J. Towle
Tallahassee, Florida

Tech Memo No. 61
July 31, 1971

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ABSTRACT

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Interaction of Abilities and Anxiety with Availability of Objectives and/or Test Items on Computer-Based Task Performance[1]

Paul F. Merrill and Nelson J. Towle
Florida State University

Even though Mager's (1961) classical book on preparing objectives has been widely accepted by the educational community, there are those (Eisner, 1967a; Kliebard, 1968) who question the value of objectives and feel they might actually be a hindrance to the design of instruction. However, Eisner (1967b) has pointed out that the contribution of behavioral objectives to curriculum construction, teaching, and learning is an empirical problem, while the little research that has been done is at best inconclusive. In an earlier study Merrill (1970) investigated the effects of objectives on the learning process and found that objectives reduced test-item-response latency and the number of examples required to meet criterion performance. A significant objective by rule interaction with test-item-response latency as criterion revealed that objectives had a greater effect in reducing response latency when added to a task which had no other focusing or organizing stimuli than they did when added to a task which had other effective orienting stimuli such as rules. On the basis of these results, it was concluded that it is impossible to make broad or general statements about the effect of objectives on the learning process without taking into account other stimulus properties of the task.

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[1] Paper presented at the annual meeting of the American Psychological Association, Washington, D.C., September, 1971.

Since all Ss in the earlier study were required to reach a minimum criterion performance at each level of the task before they were allowed to go on to the next level, the effects of objectives on a terminal criterion posttest and the interactive effects of objectives and intratask criterion test items could not be determined. Therefore, an extension of the earlier study was conducted to investigate the differential and interactive effects of the availability of behavioral objectives and criterion test items on the learning process.

Based on the results of the previous study, it was hypothesized that the presentation of objectives would increase the amount of time subjects spent studying example displays and objectives and would decrease test-item-response latency. Objectives were also expected to decrease the relationship between reasoning ability and test-item-response latency. It was further hypothesized that objectives and/or criterion test items would facilitate performance on the terminal criterion posttest. In addition to the above, the relationships between the instructional treatments and state-trait anxiety were investigated for exploratory purposes.

Method

Subjects

The 132 Ss who participated in this study were recruited from introductory psychology classes at Florida State University and received class credit for their participation. Nine of the original Ss were eliminated because they failed to complete both phases of the study.

Aptitude Measures

A battery of four cognitive ability tests and a trait anxiety scale were administered to all Ss in group testing sessions. The battery consisted of two tests (Letter Sets and Ship Destination) selected from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963) and two task-relevant tests (Bi-Column Number Series and Tote Mobile) developed by Merrill (1970). The task relevant tests required Ss to process the same type of information that must be processed in the learning task, while the Kit tests required similar processes on information not related to the task. The final test in the battery was the A-Trait scale of the State-Trait Anxiety Inventory developed by Spielberger, Gorsuch, & Lushene (1970). A short form of the A-State scale from the State-Trait Anxiety Inventory (O'Neil, 1970) was given at three points during the task.

Experimental Task and Materials

The learning task consisted of an imaginary science called the Science of Xenograde Systems (Merrill, 1970). The structure and content of the task were similar to those of formal science topics, but the imaginary nature of the science assured that none of the Ss had any previous experience with the task. The subject matter of the science dealt with the principles or rules by which the activity of small particles which make up a Xenograde system could be predicted. The instructional program consisted of 10 modules. The materials for each module included a statement of a subobjective, an example of a rule of the science, and a constructed-response criterion test item. The examples were in the form of partial Xenograde system tables which showed the activity and relationships

of the particles of Xenograde system at several points in time. The examples, objectives, and test items for the 10 modules may be found in Appendix A. A printed instruction booklet was also provided which contained an introduction to the Science, instructions on reading Xenograde tables, and a treatment specific explanation of the procedure for learning the task. A sample booklet is found in Appendix B.

The terminal objective of the task required that Ss predict the state of Xenograde system particles at successive time intervals given information of the previous state of the particles. Achievement of the terminal objective was assessed by a posttest which required Ss to record their predictions by making four entries in each of 18 Xenograde tables. The posttest may be found in Appendix C. The instructional program and posttest were written in the Coursewriter II language and presented on a cathode ray tube terminal by the IBM 1500 computer-assisted instruction system.

Procedure

After the administration of the ability test battery and the A-Trait Scale, the Ss were randomly assigned to four groups: an example-only group (n=30), and objective-example group (n=31), a test-example group (n=31), and an objective-test-example group (n=31). Figure 1 is a graphical representation of the 2 x 2 factorial design formed by these groups. In learning the imaginary science, Ss in the objective-test-example group received an example of the first rule of the science and a statement of the corresponding subobjective displayed on a cathode ray tube terminal. After studying the example and objective, each S responded to a criterion-referenced test item requiring him to

OBJECTIVES	TEST ITEMS	
	NO	YES
NO	EXAMPLE ONLY "E" ($\underline{n}$ = 30)	TEST-EXAMPLE "T" ($\underline{n}$ = 31)
YES	OBJECTIVE-EXAMPLE "O" ($\underline{n}$ = 31)	OBJECTIVE-TEST-EXAMPLE "OT" ($\underline{n}$ = 31)

Figure 1.--2 x 2 Factorial design used in this study.

predict certain values using the rule inferred from the example. This procedure was repeated until all 10 rules of the science had been presented. The Ss in the other three groups learned the science by the same basic procedure except for the following treatment differences. The objective-example group did not receive the test items; the test-example group did not receive statements of the objectives; and the example-only group received neither objectives nor criterion-referenced test items. After completing the 10 modules all Ss were administered a posttest presented on the computer terminals. A short form of the

A-State scale was presented via computer terminal to all Ss prior to the learning task, immediately following the task, and on completion of the posttest.

Results

In addition to total scores on the four cognitive ability tests, A-Trait scale, A-State scale, and the posttest mentioned in the previous section, display latency was obtained for each S. Data were also obtained for Ss in the test-example and objective-test-example groups on intratask test-item-response latency. Test-item-response latency was the total time required by S to respond to the intratask criterion test items while display latency was the total time Ss spent studying the examples, and, depending upon S's treatment group, the corresponding objective.

Descriptive statistics and reliability coefficients for the ability tests and the A-Trait scale are found in Table 1. Time constraints made it impossible to administer parallel forms of these tests. The reliability coefficients were estimated using the Kuder-Richardson formula 20 (KR-20). Although the ability tests were not pure speeded tests, they were timed. Therefore, the KR-20 coefficients for these tests should be interpreted with caution. The reliability coefficient of the posttest, which was not speeded, was estimated to be .88 by using the KR-20 formula.

The means and standard deviations for each group on the posttest and display latency may be found in Table 2. These criterion measures were analyzed using a two-factor analysis of variance with objectives and test items as factors. A significant objective effect ($F = 11.36$, $df = 1,119$, $p \leq .01$) was obtained using display latency as the criterion where the presentation of objectives increased the amount of time Ss spent

studying the example displays. However, no significant differences were obtained using posttest scores as criterion.

TABLE 1

Descriptive Statistics of Ability and A-Trait Measures

TESTS	NUMBER OF ITEMS	MEANS	S.D.	RELIABILITY
Letter Sets Test	15	10.7	2.2	.61
Bi-Column Number Series	18	10.9	4.3	.87
Ship Destination	24	13.4	4.5	.87
Tote Mobile	15	6.5	2.4	.73
A-Trait	20	37.7	9.0	.89

TABLE 2

Group Means and Standard Deviations for Posttest,

Display Latency, and Test-Item-Response Latency

Group	Posttest		Display Latency		Test-Item-Response Latency	
	Means	SD	Means	SD	Means	SD
Example Only	52.87	9.36	483.51	231.32	--	--
Objective-Example	50.94	9.60	607.62	224.36	--	--
Test-Example	52.58	9.37	491.34	185.39	407.39	145.62
Objective-Test-Example	53.81	8.67	632.04	227.43	378.14	182.74

Table 2 also presents the means and standard deviations for the test-example and objective-test-example groups on test-item-response latency. This criterion measure was evaluated using a one-way analysis of variance. However, the difference between groups was not significant.

Regression analyses of the individual ability scores, A-Trait scores, and the criterion measures were conducted. A significant ability by treatment interaction ($F = 3.41$, $df = 3,115$, $p < .05$) was obtained using display latency as the criterion measure and Bi-Column Number Series Test scores as the covariable. A graph of the interaction is found in Figure 2. The slope of the regression lines reveals that display latency had a negative relationship with ability scores for Ss in the test-example and objective-test-examples groups, but was not related to the ability scores of the example-only and objective-example groups.

The group means and standard deviations on the pretask A-State scale, the after-task A-State scale, and the after posttest A-State scale are presented in Table 3. Each of the A-State measures were evaluated by

TABLE 3

Group Means and Standard Deviations for

the A-State Scale of the State-Trait Anxiety Inventory

Groups		Pre Task A-State	After Task A-State	After Posttest A-State
Example Only	Mean	10.33	10.80	10.20
	SD	3.32	4.11	4.43
Objective-Example	Mean	9.58	11.55	11.19
	SD	2.85	4.19	4.44
Test-Example	Mean	9.26	10.58	11.52
	SD	3.08	3.43	4.11
Objective-Test-Example	Mean	10.39	10.16	11.32
	SD	2.86	2.91	3.23

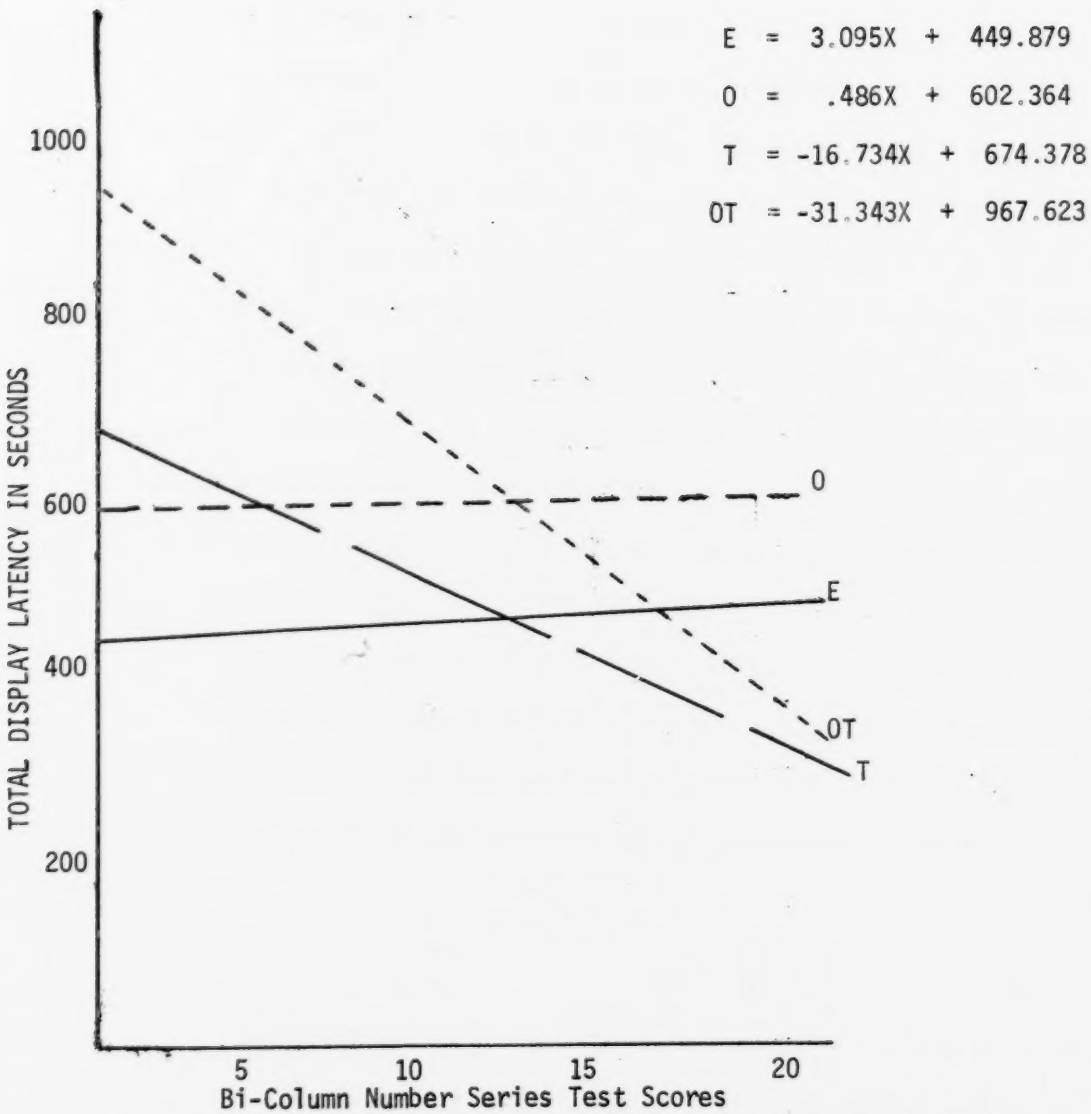

Figure 2.--Interaction of Bi-Column Number Series Test Scores and Example Only (E), Objective-Example (O), Test-Example (T), and Objective-Test-Example (OT) Treatments with Total Display Latency as Criterion.

two-factor analysis of variance with objectives and test items as factors. However, no significant treatment effects were obtained. These data were further evaluated by a three factor analysis of variance in which objectives, test items, and task periods were the independent variables with repeated A-State measures on the last factor. The results of this analysis revealed a significant period effect ($F = 7.37$, $df = 2,238$, $p < .01$), with the level of A-State generally increasing across task periods. In addition, a significant triple interaction ($F = 3.82$, $df = 2,238$, $p < .05$) was obtained.

Regression analyses of the A-State scores and the criteria were conducted. The procedures and models described by Bottenberg and Ward (1963; p. 88) for the analysis of treatment effects when covariables are influenced by treatments were used. Although there were no A-State by treatment interactions which reached the .05 level of significance, an after-task A-State by treatment interaction approached significance ($F = 2.438$, $df = 3,115$, $p < .10$). The slopes of the regression lines (Figure 3) indicate a possible positive relationship between display latency and A-State for Ss in the objective-example and test-example groups, and little or no relationship in the example-only or objective-test-example groups.

Discussion

The purpose of this study was to investigate the interactive effects of objectives and/or test items on the learning process. On the basis of results from an earlier study (Merrill, 1970) it was expected that objectives would increase display latency and decrease test-item-response latency. A significant objective effect on display

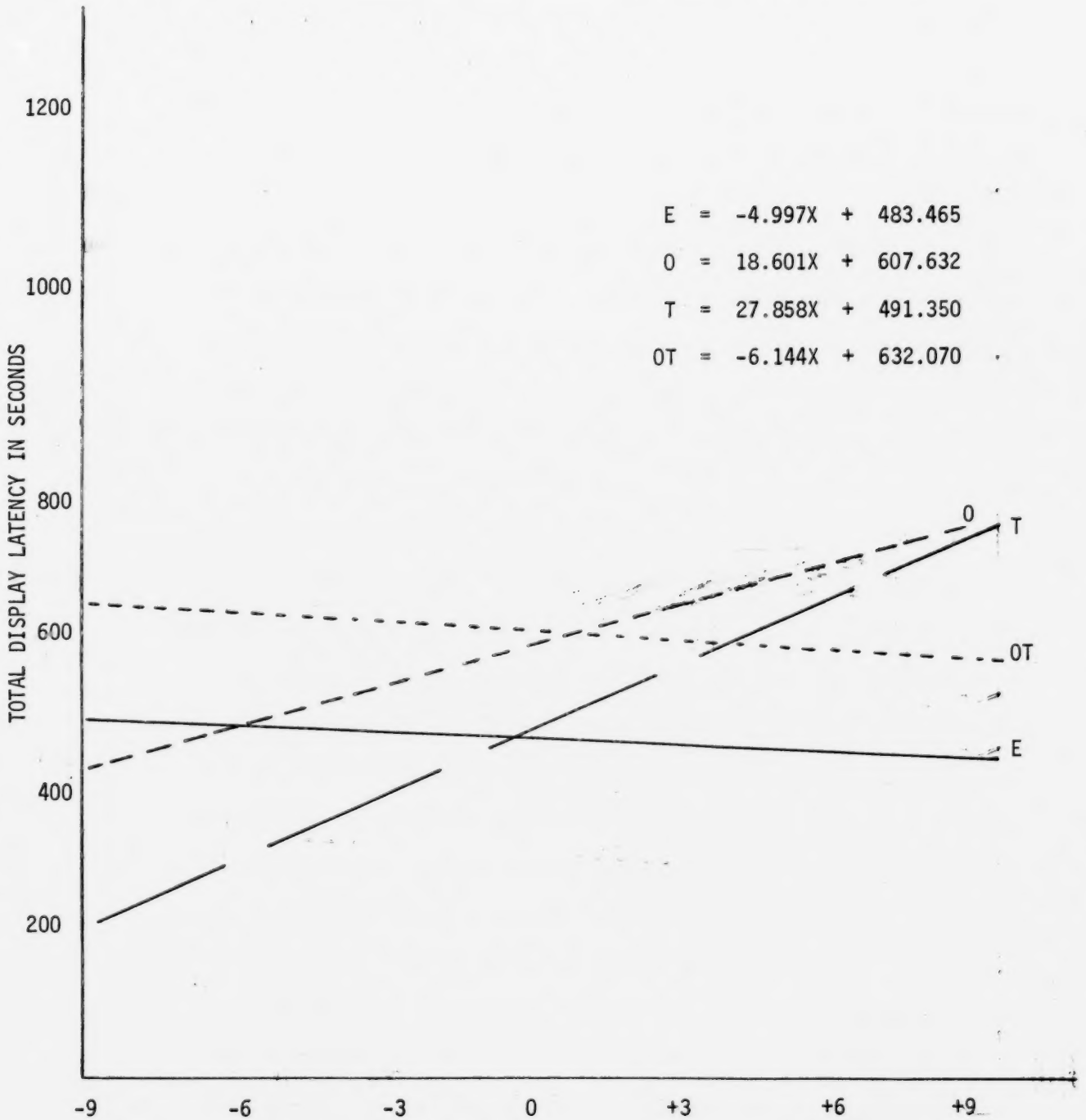

Figure 3.--Interaction of After-task A-State Deviation Scores and Example Only (E), Objective-Example (O), Test-Example (T), and Objective-Test-Example (OT) Treatments with Total Display Latency as Criterion.

latency supports the first hypothesis and shows that Ss who received objectives spent more time studying the examples and corresponding objectives than those Ss who received no statements of the objectives. However, this effect should be interpreted in light of the ability and A-State by treatment interactions found using display latency as criterion.

The hypothesis that objectives would reduce test-item-response latency was not supported by the data. The fact that subjects in the present study were only allowed to receive one example while subjects in the prior study were required to receive additional examples until criterion performance was reached may account for the discrepancy between the two studies.

Since all subjects in the prior study were required to reach a minimum criterion performance at each level of the task before they were allowed to go to the next level, treatment differences were not expected or observed on the terminal posttest. However, since all Ss in the present study received the same number of examples, it was hypothesized that objectives and/or test items would facilitate performance on the terminal posttest. The results of this study did not support this expectation and seem to indicate that the presentation of objectives and/or test items does not increase terminal criterion performance.

The lack of treatment effects on state anxiety may be due to the fact that Ss were not given any feedback concerning their performance during the learning task or the posttest. Apparently, because of this lack of feedback and the imaginary nature of the science, the Ss had

cues as to how well they were doing, and the treatments did not differentially effect their level of A-State. Therefore, additional research is needed to investigate the interactive effects of objectives and feedback on level of A-State.

REFERENCES

Bottenberg, R. A., & Ward, J. H. Applied multiple linear regression. Technical Documentary Report, PRL-TDR-63-6. Lackland Air Force Base, Texas: 6570th Personnel Research Laboratory, 1963.

Eisner, E. W. Educational objectives: Help or hindrance. School Review, 1967, 75, 250-260. (a)

Eisner, E. W. A response to my critics. School Review, 1967, 75, 277-282. (b)

French, J. W., Ekstrom, R. B., & Price, L. A. Manual for kit of reference tests for cognitive factors. Princeton, N.J.,: Educational Testing Service, 1963.

Kliebard, H. M. Curricular objectives and evaluation: A reassessment. High School Journal, 1968, 51, 241-247.

Mager, R. F. Preparing objectives for programmed instruction. San Francisco: Fearon, 1961.

Merrill, P. F. Interaction of cognitive abilities with availability of behavioral objectives in learning a hierarchical task by computer-assisted instruction. Technical Report No. 5, Austin, Texas: CAI Laboratory, University of Texas, 1970.

O'Neil, H. F. Effects of stress on state anxiety and performance in computer-assisted learning. Technical Report No. 6, Tallahassee, Florida: Center for CAI, Florida State University, 1970.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. Manual for the state-trait anxiety inventory. Palo Alto: Consulting Psychologist Press, 1970.

APPENDIX A

XENOGRADE EXAMPLES, OBJECTIVES, AND TEST ITEMS

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	6		60	3
1	6		57	3
2	6		54	3
3	6		51	3
4	6		48	3
5	6		45	3
6	6		42	3
7	6		39	3

OBJECTIVE: Given that F.F. = 1, and the values of ACS and the previous distance predict the value of the next distance.

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			49	7
1			?	7

What is the value of the distance at time 1? ?

F.F. = 4

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	8		64	1
1	8		60	1
2	8		56	1
3	8		52	1
4	8		48	1
5	8		44	1
6	8		40	1
7	8		36	1

OBJECTIVE: Given that ACS = 1, and the values of F.F. and the previous distance predict the value of the next distance

F.F. = 5

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			75	1
1			?	1

What is the value of the distance at time 1? ___?___

F.F. = 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	7		90	2
1	7		84	2
2	7		78	2
3	7		72	2
4	7		66	2
5	7		60	2
6	7		54	2
7	7		48	2
8	7		42	2

OBJECTIVE: Given the values of F.F., ACS and the previous distance, predict the value of the next distance.

F.F. = 4

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			24	3
1			?	3

What is the value of the distance at time 1? ?

F.F. = 2

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	2		72	3
1	2		66	3
2	2		60	3
3	2		54	3
4	2		48	3
5	2		42	3
6	2		36	3
7	2		30	3

OBJECTIVE: Given the previous values of ACN and ACS, and that no blip has occurred, predict the next values of ACN and ACS

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	2		32	8
1				
2	?			

At time 2 what is the value of ACN? ?

At time 2 what is the value of ACS? ?

F.F. = 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	7		90	5
1	7		75	5
2	7		60	5
3	7		45	5
4	7		30	5
5	7		15	5
6	6	6	0	6
7	6		18	6

OBJECTIVE: Given the value of the time that a blip has occurred, predict the blip time and the value of the distance at that time.

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			15	
1			12	
2			9	
3			6	
4			3	
5		?	0	
6			2	
7			4	

What is the blip time?

F.F. = 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	3		36	3
1	3		27	3
2	3		18	3
3	3		9	3
4	2	4	0	4
5	2		12	4
6	2		24	4
7	2		36	4

OBJECTIVE: Given the previous values of ACN and ACS, and that the blip time is even, predict the next values of ACN and ACS.

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
30	6		16	8
31	6		8	8
32	?	32	0	

At time 32 what is the value of ACN? _____

At time 32 what is the value of ACS? _____

F.F. = 2

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	3		60	6
1	3		48	6
2	3		36	6
3	3		24	6
4	3		12	6
5	4	5	0	5
6	4		10	5
7	4		20	5

OBJECTIVE: Given the previous values of ACN and ACS, and that the blip time is odd, predict the next values of ACN and ACS.

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
47	5		14	7
48	5		7	7
49	?	49	0	

At time 49 what is the value of ACN? ____

At time 49 what is the value of ACS? ____

F.F. = 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	0		54	3
1	0		45	3
2	0		36	3
3	0		27	3
4	0		18	3
5	0		9	3
6	0		0	3
7	0		9	3

OBJECTIVE: Given the previous values of ACS, that the blip time is even, and that ACN was zero on the previous line, predict the next values of ACN and ACS.

F.F. = 2

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
36	0		32	8
37	0		16	8
38	?	38	0	

At time 38 what is the value of ACN? ____

At time 38 what is the value of ACS? ____

F.F. = 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	3		30	2
1	3		24	2
2	3		18	2
3	3		12	2
4	3		6	2
5	4		0	1
6	4	5	3	1
7	4		6	1
8	4		9	1

OBJECTIVE: Given the values of F.F., ACS, and that a blip has occurred, predict the next distance.

F.F. = 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.			.	.
.			.	.
.			.	.
42			12	4
43		43	0	3
44			?	3

At time 44 what is the value of the distance? ____

F.F. = 2

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	4	3	0	3
4	4		6	3
5	4		12	3
6	4		18	3
7	4		24	3
8	4		18	3

OBJECTIVE: Given the distance at time zero, predict the maximum value the distance will reach.

F.F. = 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			40	
1			35	
2			30	
.			.	
.			.	
8		8	0	
9			5	

The value of the distance will increase to what maximum value before it will start decreasing again? ____

APPENDIX B

STUDENT BOOKLET

TERMINAL OPERATION SHEET

To be able to communicate with the computer there are a few basic facts you need to know.

ENTER FUNCTION

After you have typed an answer you must signal the computer that you have finished. This is done by performing the ENTER function:

1. Press the "altn coding" key, and while holding it down, press the space bar.

2. Release both the "altn coding" key and the space bar.

Remember to press the "altn coding" key and space bar simultaneously after completing each response. Unless this is done, the computer will not continue.

ERASE

If you type one or more incorrect characters and wish to correct them:

1. Press the "altn coding" key, and while holding it down, press the "backspace" key once for each character you want to erase.

2. Release both keys, and then type the correct character or characters.

3. Perform the ENTER function.

You must correct any typing errors before you perform the ENTER function. Once the ENTER function has been performed, you cannot erase any previous characters.

NOTE:

Threre are several keys that may seem similar to other keys. For example the numeral "0" (zero) resembles the letter "O" and the numeral "1" (one) resembles the lower case "l" (el). If you want to type a number, use only the top row of keys! Failure to do this may result in the computer analyzing your response incorrectly.

INTRODUCTORY BOOKLET FOR OBTST STUDY

INTRODUCTION

Welcome to the Computer-Assisted Instruction Center, and thank you for coming. In this study we are interested in how students learn science principles when given differential types of information.

The time you spend will not give you an encyclopedia of facts, but it may improve your skills of observation, inference, prediction, data interpretation, and hypothesis testing. The program has the challenge of a complex game and should be interesting in its own right.

The instructional program concerns an imaginary science called the Science of Xenograde Systems. A Xenograde System consists of a nucleus with an orbiting satellite. The satellite is composed of small particles called alphons which may also reside in the nucleus. Under certain conditions, a satellite may collide with the nucleus. When such a collision occurs, a "blip" is said to have occurred, and the satellite may exchange alphons with the nucleus. The science deals with the laws by which the activity of satellites and alphons may be predicted.

The following diagram is one way of conceptualizing a Xenograde System:

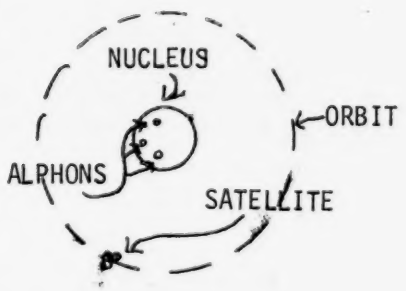

Figure 1.--Science of Xenograde Systems

INSTRUCTIONS FOR READING THE DISPLAYS

In taking this program, you will need to be able to read a tabular display on the CRT which records the activity of the particles making up a Xenograde System.

Figure 2 is a sample display.

FF = 2

System Time	ACN	Blip Time	Satellite Distance	ACS
0	2		24	3
1	2		18	3
2	2		12	3
3	2		6	3
4	1	4	0	4
5	1		8	4
6	1		16	4

Figure 2. Sample display of a Xenograde table.

The symbols stand for the following.

F F. - Force field - Physically this can be thought of as an area in space, which if entered by an Xenograde system, will exert certain predictable affects on the system. The strength of the force field can be measured and given numerical values. The effect of the force field on the Xenograde System is based on the strength of the force field.

TIME - This column serves as a clock which provides a basis for presenting the state of the system at small sequential intervals of time. It is increased by a value of 1 (one) with each reading. Notice that time always starts at time 0 (zero).

ACN - Alphon Count of the Nucleus. As the name suggests, the numerical values in the column under ACN refer to the number of alphons that are located in the nucleus at any given time. For example, in the figure the number of alphons on the nucleus at time 2 is 2 while the number of alphons on the nucleus at time 6 is 1.

BLIP TIME - In the column under this heading are recorded the value of the time clock when a blip occurs, that is when a satellite collides with the nucleus. In Figure 2 you will notice that such a collision occured at time 4.

SATELLITE DISTANCE - The values recorded in the column under this heading refer to the number of units of distance between the satellite and the nucleus. From figure two you will notice that the satellite is 24 units from the nucleus at time 0 while it is only 6 units from the nucleus at time 3.

ACS - Alphon count of the Satellite. The values recorded in the column under this heading refer to the number of alphons which make up the satellite at any given time. For example, in the Figure, the number of alphons in the satellite at time 2 is 3 while there are 4 alphons in the satellite at time 5.

⋮ - A series of three dots in any column refer to a series of values that have been skipped. For example, if the time column starts with three dots followed by the number 24, then all the values from time 0 to time 24 have been skipped.

INSTRUCTIONS FOR GROUP 1 (E)

Follow these instructions in taking the instructional program.

1. When you begin the program, a Xenograde display table will appear on the Cathode Ray Tube (CRT). Your task will be to study each table as it is presented and try to discover a rule which determines how the values in the tables change.

2. After you have studied the Xenograde table, perform the "enter" function, and you will automatically be presented the next Xenograde display table.

3. You will follow the above procedures repeatedly until the 10 rules of the science have been learned.

4. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to use the rules you have discovered to predict entries in a table of Xenograde readings when given the initial conditions.

Since the scores you make in learning these materials will not affect your grade, but will be used to answer research questions in education, we would appreciate it very much if you would refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the program. Prior knowledge of the details of the program may confound the results and make the time you have spent in vain.

Please put away your notebooks and pencils since you will not need these while you are working on the computer. One goal of this research is to investigate your ability to remember information without using notes or any reference materials.

PLEASE NOTE: If you run into difficulty, it will be very helpful for you to refer back to this booklet. Try to relate the numbers in the tables to the physical diagram and the explanation found on page 2 of this booklet.

When you are ready to begin the course, type the word "start" and then perform the "enter" function.

YOU DO NOT NEED TO READ THE FOLLOWING PAGES UNTIL THE COMPUTER DIRECTS YOU TO DO SO.

INSTRUCTION FOR GROUP 2 (EO)

Follow these instructions in taking the instructional program.

1. When you begin the program a Xenograde display table will appear on the Cathode Ray Tube (CRT). Your task will be to study each table as it is presented and try to discover a rule which determines how the values in the tables change. A statement of the objective for studying each display will be presented below the table.

2. After you have studied the objective and the Xenograde Table, perform the "enter" function, and you will automatically be presented the next Xenograde display table.

3. You will follow the above procedures repeatedly until the 10 rules of the science have been learned.

4. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to use the rules you have discovered to predict entries in a table of Xenograde readings when given the initial conditions.

Since the scores you make in learning these materials will not affect your grade, but will be used to answer research questions in education, we would appreciate it very much if you would refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the program. Prior knowledge of the details of the program may confound the results and make the time you have spent in vain.

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When you are ready to begin the course, type the word "start" and then perform the "enter" function.

YOU DO NOT NEED TO READ THE FOLLOWING PAGES UNTIL THE COMPUTER DIRECTS YOU TO DO SO.

INSTRUCTIONS FOR GROUP 3 (ET)

Follow these instructions in taking the instructional program.

1. When you begin the program a Xenograde display table will appear on the Cathode Ray Tube (CRT). Your task will be to study each table as it is presented and try to discover a rule which determines how the values in the tables change.

2. After you have studied the table, perform the "enter" function to continue.

3. You will then be given a test item. This test item will consist of a partial Xenograde table with missing values represented by a shaded box. You will be asked to predict the missing values by using the rule you have discovered. After typing in your answer and performing the ENTER Function, you will automatically be presented the next Xenograde display table.

4. You will follow the above procedures repeatedly until the 10 rules of the science have been learned.

5. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to use the rules you have discovered to predict entries in a table of Xenograde readings line by line given the initial conditions.

Since the scores you make in learning these materials will not affect your grade, but will be used to answer research questions in education, we would appreciate it very much if you would refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the program. Prior knowledge of the details of the program may confound the results and make the time you have spent in vain.

Please put away your notebooks and pencils since you will not need these while you are working on the computer. One goal of this research is to investigate your ability to remember information without using notes or any reference materials.

PLEASE NOTE: If you run into difficulty, it will be very helpful for you to refer back to this booklet. Try to relate the numbers in the tables to the physical diagram and the explanation found on page 2 of this booklet.

When you are ready to begin the course, type the word "start" and then perform the "enter" function.

YOU DO NOT NEED TO READ THE FOLLOWING PAGES UNTIL THE COMPUTER DIRECTS YOU TO DO SO.

INSTRUCTIONS FOR GROUP 4 (EOT)

Follow these instructions in taking the instructional program.

1. When you begin the program, a Xenograde display table will appear on the Cathode Ray Tube (CRT). Your task will be to study each table as it is presented and try to discover a rule which determines how the values in the tables change. A statement of the objective for studying each display will be presented below the table.

2. After you have studied the objective and the Xenograde Table, perform the "enter" function to continue.

3. You will then be given a test item. This test item will consist of a partial Xenograde table with missing values represented by a shaded box. You will be asked to predict the missing values by using the rule you have discovered. After typing in your answer and performing the ENTER Function, you will automatically be presented the next Xenograde display table.

4. You will follow the above procedures repeatedly until the 10 rules of the science have been learned.

5. After learning all the rules of the science, you will take a posttest. The posttest will assess your ability to use the rules you have discovered to predict entries in a table of Xenograde readings when given the initial conditions.

Since the scores you make in learning these materials will not affect your grade, but will be used to answer research questions in education, we would appreciate it very much if you would refrain from discussing the details of the science and posttest with fellow classmates who have not yet taken the program. Prior knowledge of the details of the program may confound the results and make the time you have spent in vain.

Please put away your notebooks and pencils since you will not need these while you are working on the computer. One goal of this research is to investigate your ability to remember information without using notes or any reference materials.

PLEASE NOTE: If you run into difficulty, it will be very helpful for you to refer back to this booklet. Try to relate the number in the tables to the physical diagram and the explanation found on page 2 of this booklet.

When you are ready to begin the course, type the word "start" and then perform the "enter" function.

YOU DO NOT NEED TO READ THE FOLLOWING PAGES UNTIL THE COMPUTER DIRECTS YOU TO DO SO.

APPENDIX C

XENOGRADE POSTTEST

POSTTEST INSTRUCTIONS

You will now take a posttest to access your ability to use the information you have learned. You will be asked to predict entries in Xenograde Tables when given certain previous conditions.

The purpose of this test is to assess your ability to use the information you have studied to predict entries in Xenograde Tables when given certain previous conditions.

For each item you will be asked to fill in an entire line of a Xenograde Table. Thus, you will make four predictions for each item. Type in the prediction that corresponds with the position of the cursor (little box). Remember to perform the "enter" function after each answer. The cursor will automatically "jump" to the next location. Do not type the next answer until the cursor appears in the appropriate location.

There may be cases where no entry should be made in the "Blip Time" column. When this occurs type the letter "b" (for blank) in the "Blip Time" column.

When you are ready to take the Posttest, type the word "begin" followed by the ENTER function.

F.F. = 2 ITEM 1

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	4		58	4
1				

F.F. = 3 ITEM 2

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		72	.
1	2		66	2
2				

F.F. = 4 ITEM 3

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
4	.		8	.
5	0		4	1
6				

F.F. = 2 ITEM 4

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			16	
.	.		.	.
.	.		.	.
6	3	6	0	3
7				

F.F. = 1 ITEM 5

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			40	
.	.		.	.
.	.		.	.
.	.		.	.
10		10		
.	.		.	.
.	.		.	.
.	.		.	.
16			30	
17	6		35	5
18				

F.F. = 2 ITEM 6

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0			24	
.	.		.	.
.	.		.	.
.	.		.	.
6		6		
.				
.				
9			18	
10	7		24	3
11				

F.F. = 3 ITEM 7

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
5	.		18	.
6	4		9	3
7				

F.F. = 4 ITEM 8

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		60	.
.	.			.
.	.			.
.	.			.
5	5	5	0	2
6				

F.F. = 5 ITEM 9

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		60	.
.	.		.	.
.	.		.	.
3	.	3	.	.
.	.		.	.
.	.		.	.
6	.		45	.
7	2		60	3
8				

F.F. = 1 ITEM 10

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
4	.		4	.
5	4		2	2
6				

F.F. = 2 ITEM 11

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		70	.
.	.		.	.
.	.		.	.
5	3	5	0	6
6				

F.F. = 3 ITEM 12

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		36	.
.	.		.	.
.	.		.	.
.	.		.	.
12	.	12	.	.
.	.		.	.
.	.		.	.
16	.		24	.
17	8		30	2
18				

F.F. = 2 ITEM 13

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
24	.		40	.
25	4		32	4
26				

F.F. = 3 ITEM 14

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
47	.		30	.
48	6		15	5
49				

F.F. = 6 ITEM 15

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		42	.
.	.		.	.
.	.		.	.
.	.		.	.
28	.	28	0	.
29	0		42	7
30				

F.F. = 7 ITEM 16

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	.		98	.
.	.		.	.
.	.		.	.
.	.		.	.
9	.		0	.
10	5		14	2
11				

F.F. = 2 ITEM 17

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
0	3		48	8
1				

F.F. = 3 ITEM 18

SYSTEM TIME	ACN	BLIP TIME	SATELLITE DISTANCE	ACS
.	.		.	.
.	.		.	.
.	.		.	.
22	.		6	.
23	7		3	1
24				